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RESEEDING RANGE LANDS OF THE INTERMOUNTAIN REGION

FARMERS' BULLETIN No. 1823
U.S. DEPARTMENT OF AGRICULTURE

REVEGETATING deteriorated range lands by sowing adaptable, nutritious, and palatable grasses is vital for adequate forage production in the Intermountain region, for profitable livestock raising, and as a safeguard against flood and erosion damage. The effect of serious droughts, greatly aggravated by overstocking, has resulted in the replacement of valuable perennial grasses by annual weeds and grasses that have much less value as forage for livestock or for proper soil protection. The abandonment of unsuccessful submarginal croplands has also added greatly to the vast acreage of deteriorated but potentially productive range lands of the region in need of revegetation.

Proper guides and procedure for revegetating run-down ranges and abandoned dry farms by artificial reseeding are necessary to safeguard against costly pitfalls and to insure reasonable success.

The procedures herein outlined are based on the experiences and research to date and should prove helpful to those administering range lands and producing livestock in the region comprising Utah, Nevada, southern Idaho, and southwestern Wyoming, commonly referred to as the Intermountain region.

Washington, D. C. Issued July 1939

RESEEDING RANGE LANDS OF THE INTERMOUNTAIN REGION

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POSSIBILITIES OF RANGE RESEEDING

A GROWING CONSCIOUSNESS of decreased forage production on the western range has given rise to a definite demand for range rehabilitation. Many land-managing agencies, both State and Federal, are projecting plans to obtain the kind of range management that will provide forage on a sustained-yield basis and also provide for a plant cover adequate to prevent abnormal soil losses and to regulate stream flow. In addition to a significant decrease in grazing capacity, deteriorated foothill and mountain ranges are not only rapidly losing their highly valuable topsoil, but in some cases by encouraging floods they are endangering whole communities in the valleys below. Deteriorated range near recreation centers destroys the beauty of the landscape and contributes to unsightly and insanitary conditions. Such areas are also highly unfavorable for desirable sorts of wildlife. This waste of soil, water, and other resources, together with the imminent risk to life and property from floods, constitutes a serious indictment of past land-management policies and is a cause of grave concern for the future.

In the Intermountain region there is in all 145,000,000 acres of range land, of which about 112,000,000 acres is deteriorated to such a degree that immediate measures for rehabilitation must be taken. Forage production on these lands is normally low and uncertain; yet all of the 5,000,000 sheep and a large part of the 1,000,000 cattle in the region depend on these ranges for a major part of their feed during 6 to 12 months of the year. The greater part of the area, approximately 100,000,000 acres, will revegetate naturally under proper range management. The remaining 12,000,000 acres, which includes numerous areas of high value for watershed and other land services, and on which deterioration of the forage cover has reached a stage that is little less than disastrous, will need to be revegetated artificially.

The restoration of these key areas is of vital importance to the welfare of the grazing industry and to other interests in the region.

Of this deteriorated land about 5,000,000 acres is abandoned cropland, largely former dry farms, with good soils and potentially the most productive spring and fall range in the region. Another 6,000,000 acres in the foothills and valley edges is in the spring and fall zone, lying mostly between the cultivated farms and the lower edge of the summer range in the higher mountains. The remainder, about a million acres, consists of so-called "sore spots" on the national forests—relatively small isolated areas where livestock were formerly allowed to concentrate and where, as a result, vegetation and soil have both deteriorated; or, in some instances, bad fire scars.

Restoration of the deteriorated but still potentially good spring and fall range is most essential, since this type of range (fig. 1) is the

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FIGURE 1.—Valuable spring and fall range so deteriorated that hardly a seed plant remains of the desirable forage grasses. Artificial reseeding is essential if such areas are to be rehabilitated and furnish sufficient nutritive forage for livestock during the critical spring and fall seasons.

bottleneck, so to speak, of the livestock industry in the Intermountain region. Not only must the spring and fall range bear the double burden of two seasons of grazing use, but unless it is in a sufficiently thrifty condition to be available early in the spring and to maintain a good stand of dry forage for fall grazing, the result is inevitable, costly overuse of the summer and winter ranges or expensive supplemental feeding.

The sore spots on the national forests and on privately owned summer range, although smaller in aggregate area than the depleted spring and fall range in need of revegetation, are no less important (fig. 2). They are for the most part burned-over areas or meadows the forage cover of which has been depleted by past overgrazing. They are located in the high mountains, from which, once the land is denuded, floodwaters descend and are likely to cause disastrous

property losses in the valleys below. Many of the costly floods in this region have been traced back to such an origin, and the evidence is equally clear that under similar conditions of slope and rainfall, where a good plant cover has been maintained, no such disastrous floods have occurred.

Is the proposal to reseed such a large area of deteriorated range a practical one? Research has shown by numerous experiments that it is, provided the natural conditions of the site are good, the vegetation introduced is adapted to the site, and proper subsequent protection and sound grazing practices are applied to the seeded area. Results of experiments on national-forest ranges as well as of actual range demonstrations of seedings by the Forest Service based on these experiments bear out this assurance. Confirmation is also given

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FIGURE 2.—One of the sore spots in the head of Parrish Canyon, Utah, on which floods have originated repeatedly. This area was recently added to the Wasatch National Forest. Once a well-vegetated and choice grazing ground, this piece of range is in urgent need of reseeding to prevent floods and to check further erosion. Such a critical area justifies an expense for reseeding or transplanting far above the anticipated value of the forage it would produce, since water collecting on the present barren area may cause further floods, damaging to agricultural lands in the valley below.

by recent experiments by the Montana, Colorado, and New Mexico Agricultural Experiment Stations, as well as by the Northern Rocky Mountain and the Southwestern Forest and Range Experiment Stations of the Forest Service. Seeding trials and demonstrations carried on by the Soil Conservation Service, the former Resettlement Administration, and other Government agencies, as well as those of private individuals, further indicate the practicability of range reseeding and have given considerable impetus to such a range-betterment program. All these tests and experiences unite in giving assurance that in the Intermountain region artificial reseeding can be reasonably sure of

success on areas having fairly heavy rainfall, not too thin a topsoil layer, and other equally favorable growing conditions, if aided by proper grazing practice.

Not all of the 12,000,000 acres in special need of rehabilitation in the Intermountain region is equally promising for artificial reseeding. About one-third of it, however, still has a fairly productive soil that will absorb precipitation water readily. This 4,000,000 acres consists largely of abandoned dry farms, mountainous and foothill range lands in both private and Federal ownership, and lower winter ranges in grazing districts that are adjacent to the national forests and to private ranges. On these lands as a whole, precipitation is at least sufficient to maintain a stand of good forage plants. Plant restoration has as good a chance here as under similarly favorable conditions on experimental areas. On such lands high hopes for range reseeding are justified, and these are the lands that should be reseeded first. Furthermore, knowledge to guide procedure on such lands has already been accumulated, whereas research in regard to the reseeding of the less favorable tracts has much yet to reveal before methods and practices can be specified in detail.

The purpose of this bulletin is to bring together present knowledge of reseeding practice in this region for the information of those engaged in reseeding operations. Effort has been made to show what procedures are considered reliable and what pitfalls must be avoided in choosing the areas on which to work, in selecting and obtaining the seed, in choosing the time for sowing and methods of getting the seed into the ground, and in the care given the newly planted lands. Directions are also included for procedure on particularly difficult sites which, because of their great watershed or other community value, are of sufficient importance to require immediate care of a more detailed and costly nature than would be justified on most wild lands. In the preparation of this bulletin, the guiding principles applying to classes of conditions have been emphasized; no attempt has been made to present precise details for individual conditions. There are two reasons for this: (1) The accumulation of information at this stage in the research program is adequate for the formulation of major principles but lacks many of the specific details which can be filled in only as investigations make headway; and (2) the extreme variety of conditions with respect to soil, slope, exposure, precipitation, temperature, and natural plant cover makes the number of individual cases almost endless. It would be impossible to include them all under anything more definite than broad guiding principles.

GUIDES IN CHOOSING AREAS FOR RESEEDING

Guiding principles in the choice of areas for reseeding are best determined from the study of type examples. Descriptions of sites and treatments where reseeding has succeeded and of those where it has failed, point to the factors contributing to success or failure. The results of this analysis, coupled with basic agronomic information known to be reliable for the region, permit the drawing of some general conclusions.

The first example is an area on Major Flat in Ephraim Canyon, in central Utah, where sowings of smooth brome,[1] mountain brome, and

[1] A list of common and botanical names of plants mentioned in this bulletin is given on p. 25.

crested wheatgrass were successful. At this place the elevation is 7,150 feet and the average annual precipitation 12 inches. The area is typical of the higher foothill ranges of central Utah, which under favorable conditions bear a growth of big sagebrush, bluebunch wheatgrass, perennial weeds, and mountain brush (chiefly Gambel oak). The soil on this site is fertile, light gray-brown, and fine-textured, containing a fairly large percentage (4 percent) of organic matter. It is also friable and easily penetrated by moisture. The surface soil is firm yet finely granular and forms a favorable seedbed for grasses. Spring and fall precipitation is usually adequate.

On this area, 6 years after reseeding experimental plots under fence, there was a marked increase in the grazing capacity as compared with

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FIGURE 3.—A good stand of slender wheatgrass in an experimental reseeding plot in the foothills near Major Flat, in Ephraim Canyon, Utah. The soil is a deep, fertile clay loam, high in organic matter and easily penetrated by water.

that of the heavily grazed adjacent range. The grazing capacity of the plots seeded to crested wheatgrass, smooth brome, and mountain brome were, respectively, 281, 719, and 222 percent higher than that of the adjacent open range. Slender wheatgrass did about as well as crested wheatgrass (fig. 3).

Similar results were obtained in reseeding trials with these species on two other vegetative types in Ephraim Canyon at higher elevations—7,890 and 8,000 feet—in the center of and at the upper limits of the oak-brush zone. Big sagebrush, serviceberry, mountain-mahogany, and bitterbrush grow in the openings between the more dense stands of gambel oak. Grasses such as slender wheatgrass, Letterman needlegrass, and mutton grass are native to these areas, although they have been largely replaced by annual weeds and low-value shrubs. The average annual precipitation on these areas is approximately 17 and 20 inches, a large percentage of it falling as snow during the winter

months. The soil is darker in color and contains appreciably more organic matter than that on Major Flat.

Remarkable success was likewise obtained with smooth brome on a fenced area at the ranger station in Oak Creek Canyon in west-central Utah, where the elevation is 5,500 feet. The soil is deep and dark-colored and absorbs water readily. The average precipitation is about 15 inches.

Reseeding to crested wheatgrass on an abandoned plowed and fenced area of 1½ acres on the United States Sheep Experiment Station at Dubois, Idaho (elevation 5,500 feet), yielded about 400 percent more forage than on unseeded adjacent range. The soil is a firm but friable, light-brown, fertile loess silt loam of basaltic origin. It absorbs water readily. As it dries, the surface 2 to 3 inches forms a crust and becomes somewhat hard. The average annual precipitation of about 10 inches, mostly in the form of snow and early spring rains, ordinarily wets the soil to a good depth.

Some 20 to 30 similar sites in the Intermountain region have yielded fairly comparable results. They are all small in area, have moderate to good precipitation, and all have deep, well-preserved soils of naturally high productivity and moisture-supplying power. On all of them livestock grazing was under control during the time the plants were becoming established.

It must be realized that conditions which on casual examination seem favorable may not necessarily assure satisfactory results. For example, on 10 to 20 acres on Philadelphia Flat in Ephraim Canyon, Utah, at nearly 10,000 feet elevation and with approximately 29 inches of precipitation annually, mountain brome, slender wheatgrass, and Kentucky bluegrass failed to maintain effective stands after each of several attempts, even though this site in early days bore a magnificent stand of grasses. Smooth brome, however, has developed a fair stand. The explanation of the failure lies in the loss through wind and water erosion of several inches of topsoil, exposing a compact clay loam. This soil is not only low in plant nutrients but also extremely deficient in organic matter; it absorbs water slowly and becomes very hard when dry. Most of the natural vegetation is now Rydberg pentstemon, a perennial weed of very low palatability, interspersed with other weedy plants. Practically no native grass occurs, except in a small cove where the topsoil has been preserved; here there is also an almost complete cover of bluegrass, the result of seeding. On the extreme west edge of the flat a few acres of dark friable soil bear a good cover of Letterman needlegrass.

In one instance in southern Utah, several thousand pounds of seed, largely Kentucky bluegrass, sowed on sites at various elevations has failed thus far to produce satisfactory stands. This failure has resulted largely from the sowing of a species unadapted to the soil and climatic conditions. Many of the soils where the seed was sown are shallow and have lost through erosion much of the topsoil, which is the most productive and also the most effective in holding available soil moisture. This loss of soil, coupled with an extremely dry season the year the seed was sown, practically precluded the germination and establishment of the grass. Kentucky bluegrass is not well adapted to conditions of this sort, as is indicated in table 1.

Seedings of smooth brome, crested wheatgrass, slender wheatgrass, or sheep fescue were complete failures on a nongrazed area in south-

western Millard County, Utah, in 1934. The normal precipitation of this area is only 7 or 8 inches annually and the vegetation is characteristically salt-desert shrub. The season was one of extreme drought; and wind erosion was very active during the period of the test.

The results from reseeding were unsatisfactory in two other instances on the southern edge of the Boise National Forest in Idaho. In one of these instances, on Willow Creek, plots of crested wheatgrass and tall oatgrass failed almost completely. Here the soil is badly eroded, and livestock could not be kept off until the plants were well started. Again, on the Danskin drainage, tall oatgrass and velvetgrass made a good growth until livestock congregated on the plots and destroyed the young plants; though soil and moisture conditions were favorable, practically none of the plants survived.

From these examples of success and failure and from the knowledge of basic agronomic conditions, five conclusions may be drawn that will be helpful guides in choosing areas on which reseeding may normally be expected to yield satisfactory improvement in the plant cover.

(1) Range or watershed areas are much more likely to yield satisfactory plant stands from artificial reseeding when there is a moderately ample supply of moisture, or approximately 12 inches or more of annual precipitation. Occasional rains during the summer months are very helpful in the establishment and maintenance of grass seedlings through the usually dry, hot summers. Areas of low and uncertain precipitation, as for example the desert-shrub winter ranges, are so unfavorable that extensive reseeding on these ranges will not be practical until more data are gathered or more drought-resistant plants than are now available have been found or developed.

(2) A fairly deep fertile soil of medium to fine texture, well supplied with organic matter and capable of holding large quantities of available moisture, is a great assurance to success in reseeding range lands. All the marked successes with reseeding previously noted were obtained on deep, rich soils that had not suffered severely from accelerated erosion. Even under favorable moisture conditions, poor soils, as on Philadelphia Flat, prevent any appreciable improvement in the plant cover following reseeding even with aggressive grasses and the best seeding methods now known.

(3) Other good site qualities that are conducive to successful reseeding include low to medium slope with some vegetation that will aid in preventing the run-off and evaporation of an unduly large part of the precipitation. The native vegetation should not, however, be so heavy as to compete seriously with or choke the seedlings. Bald southwest exposures having steep slopes are generally unfavorable, for not only is a large portion of the precipitation lost on such slopes before it can be absorbed by the soil, but evaporation also is often excessive, leaving the soil too dry for good seed germination or for maintenance of seedlings.

(4) The native plant cover that formerly occupied the area is frequently a useful guide as to what degree of success may be expected. Remnants of palatable shrubs, such as mountain snowberry, serviceberry, and bitterbrush, and of palatable grasses, especially slender wheatgrass, mountain brome, native bluegrasses, needlegrasses, or fescues, indicate that site conditions were once and probably still are favorable to the better forage grasses. The presence of only tough

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unpalatable plants or annuals should in the main be regarded as a warning that it may be difficult for the better plants to take hold and grow, though in some cases a favorable site has suffered a loss of all the better plants without the site itself having deteriorated.

(5) Of vital importance to success with reseeding is the elimination of livestock grazing for the first season after seeding and until after seed maturity the second season. This topic is discussed with some detail in a later section, Care of Newly Seeded or Planted Areas.

Certain critical areas closely related to the welfare of dependent communities demand immediate measures, regardless of unfavorable site conditions, in an effort to control soil erosion and regulate stream flow. The special measures required on these areas to assure the growth of grass are discussed later in the section, Revegetating Critical Areas.

GUIDES IN DETERMINING WHAT SEED TO SOW

The more palatable perennial grasses are in general the most effective in aiding absorption of water, holding soil against erosion, and producing abundant feed for livestock. The choice of forage plants for range reseeding depends largely, however, upon their adaptability to the conditions of the site in question. Table 1 supplies helpful aid in selecting forages with the greatest chance of survival under any given set of conditions.

It is needful also to take into account the type of range with which any given seeding area is identified. In the Intermountain region there are three general types: (1) The high mountain range, which is grazed only during the summer months; (2) the lower foothill and valley edges, grazed generally for a month or two in the spring and again in the fall; and (3) the desert valleys and ridges, which are usually grazed during the late fall, winter, and early spring months. Owing to the generally low rainfall and the relatively hot and dry summers, reseeding trials on the desert ranges so far have been rather unsuccessful. Extensive reseeding on the deserts, therefore, is not recommended until such a time as research provides more information concerning appropriate plants and methods to use. The following discussion therefore applies to mountain, foothill, and sagebrush valley ranges.

IN THE HIGH MOUNTAINS

The high mountain ranges, which extend from elevations of 6,000 to 7,500 feet up to 10,000 feet or higher, have a relatively short growing season and usually receive a larger amount of precipitation than do the foothill and desert ranges. Much of the precipitation comes as winter snow and a smaller proportion as summer rain, leaving the soil rather dry during a part of the warm growing period. The grasses best suited to high mountains are those not readily injured by severe cold or periodic drought (fig. 4).

Grasses that have done well in reseeding trials on high mountain ranges are mountain brome, smooth brome, slender wheatgrass, and bluestem and needlegrasses (fig. 5). Mountain brome has grown over a wide range of altitude, with greatest success in the aspen-fir zone. The wheatgrasses and smooth brome also have done well from the lower edges of the mountain ranges to the higher elevations. In addition to these grasses, Kentucky bluegrass and timothy grow

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FIGURE 4.—The high mountain ranges are used chiefly for summer grazing. Many bare spots on these ranges are in need of reseeding as a means of achieving erosion control and watershed protection as well as to maintain forage production. Owing to the higher precipitation here than on the lower foothill spring and fall ranges, a wider variety of grasses are suitable for reseeding.

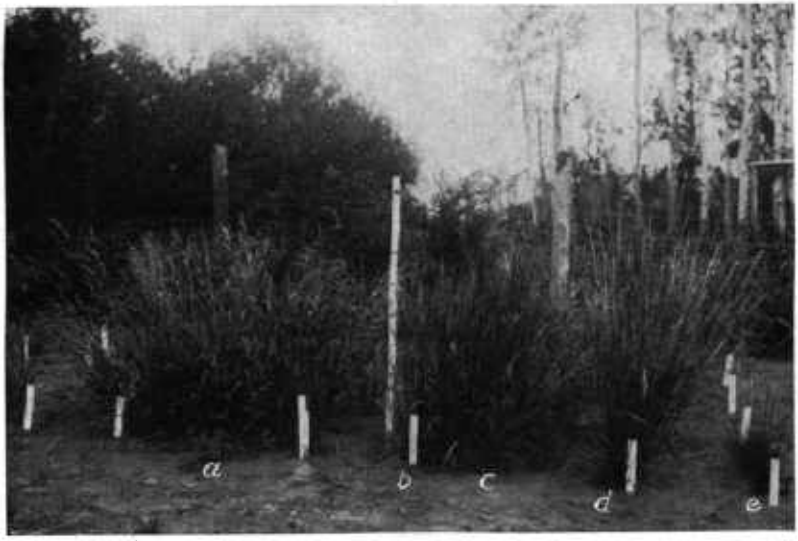

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FIGURE 5.—A group of the five desirable perennial forage grasses. The bromegrasses, mountain brome (*a*) and smooth brome (*c*), are highly palatable and bear many basal leaves. Slender wheatgrass (*b*) has a slender, upright growth and is well adapted to most high mountain ranges in the intermountain region. Needlegrasses (*d*, *e*), with basal leaves and upright flower stalks, are well adapted for reseeding.

well in mountain meadows, where the soil remains fairly moist throughout the growing period. Orchard grass has succeeded in shady places where the soil is not subject to severe drying.

TABLE 1.—*Adaptation, growth, and forage qualities, and seeding information regard region (including*

Name	Climatic adaptation	Soil adaptation	Site adaptation
Slender wheatgrass.	A native of western range lands. Very hardy and drought-resistant, but not equal to crested wheatgrass and smooth brome in these respects.	Best adapted to well-drained soils of medium to light texture (silt loams, loams, and sandy loams). Tolerant of alkali, and will grow on fairly poor soils.	Will grow and produce viable seed from the more favorable foothills to the higher mountain ranges. Thrives in dry mountain meadows. Has done well in reseeding trials on mountain ranges in Utah.
Bluestem	Native western range grass. Hardy and highly resistant to drought.	Prefers fine-textured soils, loams, silt loams, and clays which contain only a small portion of gravel and coarse rock fragments. Highly resistant to alkali.	Thrives on well-drained bottom lands, open plains, benchlands, and hillsides of the lower mountain and foothill ranges principally in the sagebrush-wheatgrass zone.
Bluebunch wheatgrass.	Native bunchgrass of intermountain region and Columbia River Basin. Extremely drought-resistant and endures much cold.	Grows on well-drained light sandy loam soils and is often the chief grass on scablands, benchlands, and on gritty, poorly disintegrated soils of low water content.	Adapted to sagebrush zone, on open dry hills, mountain slopes, and plains and will thrive on sites too dry and poor for smooth brome.
Crested wheatgrass.	Native of cold dry plains of Siberia. Extremely resistant to drought and cold, surpassing slender wheat grass and smooth brome.	Does well on productive, well-drained soils of almost any texture ranging from light sandy loam to heavy clay.	Especially adapted to foothill and lower mountain ranges.
Smooth brome	Adapted to regions of rather low rainfall and moderate summer temperature. Endures cold and drought remarkably well.	Prefers rich loams and clay loams, but will succeed on sandy soils.	Grows well from lower foothill or sagebrush zone to higher mountain ranges. Does best in aspen zone with 15 to 20 inches precipitation. Equals or surpasses crested wheatgrass on higher ranges.
Mountain brome.	Well adapted to the cooler, moister mountain areas of the West. Not as drought-resistant as smooth brome.	Grows best in fairly moist loam soils, but will grow in moderately dry clay and sandy loams. Will grow in rather poor, depleted soil.	Grows with more vigor and produces better stands in the aspen zone and on the higher ranges.
Tall oatgrass	Does not endure severe cold, but will withstand considerable summer heat. Fairly drought-resistant but not so much so as smooth brome.	Thrives on well-drained, loose deep loams and calcareous soils but succeeds also on sandy and gravelly soils.	Will probably grow best on moist sites. Will not endure shade.
Meadow fescue.	Adaptation similar to timothy. Thrives in cool, humid climate but is not suited to hot, dry climate.	Prefers rich, moist, or even wet soils. Does not succeed well in sandy land.	Probably best adapted to mountain meadows where soil is moist throughout the growing season.
Sheep fescue	Similar to Idaho fescue which is native to northern Nevada, Utah, and the Snake River plains of southern Idaho. Highly drought-resistant.	Will grow on poor and sandy or gravelly soils. Does not require as moist conditions as meadow fescue.	Adapted to dry foothills, plains, and mountainsides. Will grow on drier sites than many other grasses.

[1] Acknowledgment is made to Alvin C. Hull, Jr., junior range examiner, Intermountain Forest and

ing forage grasses and alfalfa for artificial reseeding on ranges of the Intermountain abandoned farm lands)[1]

Time and rate of seeding	Palatability and grazing capacity	Character of growth
Best sown in the fall but may be sown in midsummer on high mountain ranges or in the spring where moisture conditions are favorable—5 to 12 pounds per acre when sown alone.	Highly esteemed for palatability and nutritive value. Relished by cattle and horses throughout the year. Sheep are not so fond of the mature leafage but take the seed heads readily. Somewhat susceptible to trampling injury.	Deep-rooted, thick-tufted perennial bunchgrass. Makes stocky, leafy growth 18 to 40 inches high. Free from awns or beards. Grows slower, matures later, and yields less than crested wheatgrass. Produces good seed crop.
Best sown in the fall but may be sown in the spring where moisture conditions are favorable—8 to 15 pounds per acre.	Highly nutritious and palatable. Grazed and relished by all classes of stock. Cures well on ground and makes good winter feed. Yields somewhat less than crested wheatgrass.	Rigid, upright perennial spreading vigorously by underground rootstocks. Forms an open sod. Seed crop usually scant and seed low in viability. Becomes established slowly.
Same as for slender wheatgrass.	Young plants relished by all stock. Mature leafage not highly palatable to sheep. Will not stand heavy grazing but yields well under judicious management.	Slender bluish-stemmed perennial bunchgrass 1 to 3 feet high. Has long stout divergent or twisted awn. Poor seed producer; seed not often available on market.
Best sown in fall but may be sown in early spring where moisture conditions are favorable—3 to 8 pounds per acre sufficient when well distributed. Thin stands in beginning soon improve.	Produces an abundance of highly palatable and nutritious forage, relished by all classes of stock. Makes good pasture and yields well under seemingly adverse conditions.	Hardy, long-lived, drought-resistant perennial bunchgrass. Makes rapid and early growth in spring, is dormant during hot, dry periods of summer, and resumes growth in fall. Produces viable seed in abundance. Very aggressive when once established.
Sow 8 to 15 pounds per acre in late fall preferably, but may be sown in early spring where moisture conditions are favorable.	Grows early in the spring, produces abundance of highly palatable forage, and makes good pasture relished by all stock.	Hardy long-lived perennial, produces many underground rootstocks, forming a dense sod under favorable conditions. Grows 2 to 4 feet high and produces numerous basal leaves. Has done well in reseeding tests.
Best sown in late fall but may be sown in midsummer on high mountain ranges or in early spring where moisture conditions are favorable—10 to 15 pounds per acre.	Grazed closely by all classes of stock when young. Becomes somewhat unpalatable to sheep at maturity. Large seed heads relished by all stock.	Perennial without rootstocks. Grows in thinner stands than common brome, but yields abundance of forage 3 to 4 feet high, produces good seed crop, and spreads without difficulty. Seed usually not on market.
Best sown in late fall or early spring where moisture conditions are favorable—8 to 15 pounds per acre.	Nutritious and palatable when stock become accustomed to it.	Long-lived, deep-rooted, hardy perennial bunchgrass. Green from early spring to late fall. Seed often low in viability.
Best sown late in fall but may be sown in midsummer on high mountain ranges or in very early spring—8 to 15 pounds per acre when sown alone.	Is good pasture grass on moist soils. Very palatable and nutritious.	A tufted, deep-rooted perennial without rootstocks. Makes a fairly good sod under favorable conditions. Best sown in mixture with timothy or Kentucky bluegrass.
Same as for crested wheatgrass.	Nutritious and highly palatable, especially to sheep. Withstands close grazing.	Small perennial bunchgrass with abundant deep strong roots. Forms dense tufts 3 to 6 inches in diameter with numerous erect bluish-green leaves 2 to 4 inches long.

Range Experiment Station, who verified a large part of the information given in this table.

TABLE 1.—*Adaptation, growth, and forage qualities, and seeding information regard region (including abandoned*

Name	Climatic adaptation	Soil adaptation	Site adaptation
Kentucky bluegrass.	Grows best in a moderately moist, cool climate. Resistant to cold but languishes in hot dry weather.	Prefers rich, well-drained loams or clay loams. On poor soil it is never abundant. Not drought-resistant.	Thrives in moist mountain meadows. Will not grow on dry sites or in shady places.
Canada bluegrass.	Adaptation generally the same as Kentucky bluegrass, but is more resistant to summer heat and to drought.	Will grow on poorer soils than Kentucky bluegrass, succeeding on gravels and on thin soils over rock or clay.	Will grow on drier sites than Kentucky bluegrass, and is not adapted to moist or wet areas. Does not succeed in shade.
Bulbous bluegrass.	Grows best in moderate climate and at medium elevation. More drought-resistant than Kentucky bluegrass.	Grows on variety of soils from coarse to fine texture (sandy loams to clays).	Probably best adapted to lower foothill ranges used for early spring grazing. Requires moist soils.
Perennial ryegrass, Italian ryegrass.	Primarily adapted to moist regions with mild winter climate. Continue to grow at low temperatures but will not withstand severe winter cold. Do not withstand hot, dry weather.	Grow best on rich soils of medium to fine texture. Do not do well on sandy soils.	Thrive on moist, well-drained sites.
Timothy	Northern grass, thrives well in cool, humid climate, but is not suited to hot, dry climate.	Will succeed on wide range of soils but grows best on fine textured soils (clay loams and silt loams).	Best adapted to moist mountain meadows and sites where soil is fairly moist throughout growing season.
Orchard grass	Does not stand cold as well as timothy but is somewhat more drought-resistant. May be injured by late spring frosts.	Best adapted to clays or clay loams. Prefers a moderate amount of moisture and will grow in wet soils.	Succeeds well in shady places, with moderate soil moisture.
Sudan grass	Requires a warm climate for best development; upper altitudinal limit in Intermountain region is 5,000 to 6,000 feet. Dought-resistant.	Best adapted to well-drained rich loams but will grow on wide variety of soils. Does not tolerate alkali.	Best adapted to the more favorable southwest exposures in direct sunshine. Does poorly on cold wet sites.
Rye	Adapted to cool climates and regions of cold winters; hardier than wheat.	Responds to good soils but will produce a good crop on poor soils. May be grown on almost all soil types but especially adapted to soils of medium to coarse texture (loams and sandy loams).	Will grow on foothill and high mountain ranges. Best adapted to sites similar to those used for dry farming.
Alfalfa	Grows best in semiarid climate. May be injured by severe cold. Young plants are often destroyed by heaving of the soil caused by alternate freezing and thawing.	A deep, fertile, well-drained soil permits best development. Mature plants tolerate considerable alkali but will not grow in waterlogged soils.	Best suited to the more favorable sites on foothill ranges and valley edges. May prove valuable on abandoned dry farms.

ing forage grasses and alfalfa for artificial reseeding on ranges of the Intermountain farm lands)—Continued

Time and rate of seeding	Palatability and grazing capacity	Character of growth
Best sown in fall or early spring at rate of 5 to 10 pounds per acre.	Very highly palatable and nutritious, relished by all classes of stock. Grows early in spring and late in fall.	Hardy, long-lived perennial spreading by short underground rootstocks. Becomes established slowly and does not form sod until second or third year.
Best sown late in fall or very early spring—5 to 10 pounds per acre when sown alone.	Highly palatable and relished by all stock. Withstands moderately close grazing.	A hardy perennial similar to Kentucky bluegrass. Produces abundant rootstocks and forms a tough sod under favorable conditions.
Early fall seeding preferable—5 to 10 pounds per acre.	Highly palatable and nutritious. Forage yield medium to low.	Perennial, reproducing by bulbs at base of stem and by bulbils produced in place of seed. Grows very early in spring, dries down in hot summer, and begins growth again in the fall.
Preferably sown in early spring at rate of 8 to 15 pounds per acre. Less seed may be sown in mixtures.	Very palatable and nutritious, and produce a large quantity of forage for 1 or 2 years.	Short-lived, rapidly growing perennials, living only 2 or 3 years on poor lands but longer under favorable conditions.
Best sown in fall or early spring in mixture with other grasses at rate of 4 or 5 pounds per acre—8 to 12 pounds when sown alone.	Produces abundance of nutritious herbage. Relished by all stock.	Hardy perennial producing a tall and leafy luxuriant growth on moist soils. Becomes established quickly and produces well the second year. Does not withstand close grazing.
Best sown in late fall or early spring—5 to 10 pounds per acre.	Palatability medium to high. Makes excellent early pasture where adapted.	Long-lived perennial, forming distinct bunches with dense circular tufts. Spring growth is more abundant and earlier than timothy. Also grows late in the fall. Best sown in mixtures.
Must be sown in spring, preferably after late frosts when soil has become warm—10 to 20 pounds per acre.	Produces an abundance of forage, yielding more than most grasses where it will grow. Nutritious and eagerly eaten by all stock.	Strictly an annual. Grows rapidly to a height of 3 to 6 feet. Produces numerous broad leaves. Tillers freely. Will furnish forage while perennial grasses are getting started.
Preferably late summer and fall but may be sown in the spring—about 20 pounds per acre with other grasses or 30 to 60 pounds when sown alone.	Highly palatable and nutritious. Makes good fall and spring pasture.	An annual very similar to wheat. Grows rapidly, will furnish forage while perennial grasses are getting started.
Best sown in early spring or summer at 5 to 10 pounds per acre. Inoculation of seed before planting is advisable.	Very highly palatable and nutritious. Produces abundance of forage, but will not stand continuous close grazing.	A deep-rooted perennial of the legume family. Grows from 1 to 2 feet high, producing a very desirable, fine, leafy forage.

ON LOWER SLOPES

On the lower foothills and valley edges, which correspond to the sagebrush-wheatgrass type, the more favorable mesas or benchlands in need of reseeding have been broken up in many places and used principally for dry farming. Where dry farming has proved unprofitable and the lands have been left idle, they should be returned to range. On such abandoned lands reseeding to grasses of high forage quality will usually produce satisfactory stands. The elevation of the foothills, usually varies from 4,500 to 5,000 feet, but the desert mountain ranges run up to 6,000 or 7,500 feet. Average annual precipitation in most of the foothill zone is 10 to 15 inches, with extremes of 8 and 20 inches. Usually most of the precipitation is in the form of snow, only occasional showers coming during the growing season. Because the soil moisture is usually low during the summer months, only the most drought-resistant or early growing grasses are adapted to these ranges.

On these lands the wheatgrasses have given good results in many places. Crested wheatgrass seems to be particularly well adapted, especially in the northern part of the region; it has done well on range lands of the Snake River plains of southern Idaho, and on abandoned dry-farm lands of northern Utah and southern Idaho. It has also grown well on the foothill and lower mountain ranges. Bluestem grows well on the heavier soils and on the moister sites. Bluebunch wheatgrass has succeeded fairly well in artificial-reseeding trials in protected locations on the coarse-textured and rather porous soils of these ranges. Slender wheatgrass and smooth brome are adapted to the more favorable sites and to the higher slopes where there is somewhat more precipitation. Rye and alfalfa have thrived on areas similar to those cultivated for dry farming.

Since range soils vary so widely, it is essential that full consideration be given to the adaptability of the various grasses to the soils on which they are to be sown, as indicated in table 1. It is as unwise to sow grasses on soils to which they are not adapted as to sow them on ranges having unfavorable climatic conditions. In determining the grass or grasses best suited for sowing on a given site, it is good practice to be guided by the plant species that grow there naturally and are well-adapted to the particular soil and climatic conditions. One or more of these, or a species having similar growth requirements, may well be chosen for reseeding. Even grasses not native to the area, if they are closely related or similar to the native grasses in their growth requirements, may often be well-adapted for reseeding. Smooth brome, for example, is not native to the western range country but grows well on mountainous areas to which mountain brome and slender wheatgrass are native. Likewise, crested wheatgrass has proved well adapted to the lower foothills and valley edges where the bluestem and bluebunch wheatgrass thrive.

HOW TO OBTAIN SEED

Seed dealers, especially the larger ones, have in recent years stocked a rather wide variety of commercial grass seed of the sorts usually used for reseeding. After poor seed years or during periods of great demand, the species most favored are likely to be high-priced or even difficult to obtain at any price. In such cases, and for some ranges

seeds of adapted native species are necessary, and these can be obtained only by field collection. Where sufficient labor is available, the seed of such grasses as the bromes and wheatgrasses may be collected by hand without special difficulty. Comb seed strippers have been used successfully for collecting the seed of mountain brome and slender wheatgrass in the Wasatch Mountains in Utah. In other localities machine seed strippers, drawn by horse or motor, have been successful. Many seeds are stripped off by hand. Also, clean and ripe seed has been easily and quickly collected by shaking the ripened grass seed stalks into sacks without removing the stalks from the plants.

If possible, commercial seeds should be not more than one or two seed generations removed from stock grown under arid conditions and in a locality where the winters are at least as severe as those of the region in which the seeds are to be sown; otherwise the young seedlings that start growth may soon die because they are unable to withstand the growing conditions of the site. Reliable dealers furnish dependable information concerning the species, the purity, and the germination of the seed they sell. It pays to use seed of high purity and high germination.

WHEN TO SOW

The best time to sow grass seed in the Intermountain region is determined by seasonal and moisture conditions. Since a dependable moisture supply is all-important for effective germination of grass seed and for the establishment of grass plants, it is safer to sow the seed just before the rainy period for the locality is most likely to occur.

On this basis, July and August are favorable months for sowing in the high mountains, which normally receive several summer and autumn rains. Also favorable in the mountain and the upper foothill zones are late autumn, just before winter sets in, and very early spring, just before or immediately after the snow disappears.

In the lower foothills and valley edges—especially on abandoned farm land where a reasonably good seedbed occurs naturally or has been provided by tillage—the most favorable time for sowing grass seed is the same as that for dry-farm wheat. In most localities this is between the latter part of August and the middle of October. It is hard to specify the best time more precisely since it necessarily varies within this period for each major locality and for different seasons. Where the autumn precipitation is very low it may be unwise to sow as early as this, since if germination is started and then stopped by a protracted dry period the sprouts are likely to die. In this case late fall sowing is advisable in order that the seed may be ready to germinate at the earliest possible date in the spring.

In the foothill and valley zones, spring sowing with a drill is best done as early as the soil will permit the use of machinery. When no drill is to be used, the best time is as soon as possible after the melting of the snow.

SEEDBED PREPARATION AND COVERING THE SEED

On a large part of the range lands in need of reseeding—possibly 50 to 60 percent of the area—seedbed preparation prior to planting

is not feasible, owing either to the steep or rough topography or to the expense involved. This, however, does not preclude the possibility of success in reseeding. Seed sown on good soils late in the autumn may fall into the numerous small fissures and cracks resulting from the alternate freezing and thawing of the surface soil. Here the seed may be covered by further disturbance of the soil brought about by frost or surface water and germinate the following spring as the snow melts and the soil becomes warm. Superficially this seems the easiest and cheapest method of seeding; but a considerable

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FIGURE 6.—On lands where the soil is easily tillable a good seedbed can be prepared with a spike-tooth harrow. Seed sown broadcast before harrowing will be covered sufficiently to aid germination and seedling development.

element of chance is involved, and success is much less certain than on those areas where steps can be taken to prepare the seedbed or cover the seed, or both.

The best seedbed for grasses is one having a fairly deep and firm soil beneath 1 or 2 inches of loose and fine-textured topsoil. Here seed may be covered more readily, and quick germination and early development of the seedlings will be encouraged by more favorable moisture conditions. Although in most instances the expense involved is a prohibitive item, preparation of seedbeds should be under-

taken wherever possible, to provide a favorable start for the young plants.

Ordinarily on compact soils bearing heavy stands of weeds, disking will remove the weeds sufficiently to permit the use of a grain drill and also put the soil in good condition for seeding. Loose soils may be sufficiently worked with a spike-tooth harrow (fig. 6). Disking or harrowing has been found especially suitable in brush areas having soils favorable for high forage yields. Small open areas interspersed with clumps of tall brush, such as serviceberry or oak can be thus prepared satisfactorily at reasonable cost. In most cases where the weed growth is small and the soils not particularly compact, drilling among annual weeds is equally satisfactory. On abandoned cultivated land from which the better native vegetation has been removed

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FIGURE 7.—Contour furrows spaced 2 to 4 feet apart at right angles with the slope afford an effective seedbed at comparatively low cost. After the seed is broadcast over the freshly-plowed furrows, it may be covered effectively with a brush drag or spike-tooth harrow.

and where weeds—usually Russian-thistle—have grown up, the seedbed may be prepared by disking or harrowing, or even by plowing.

Plowing is too expensive except in particularly favorable spots where forage production great enough for hay is expected or on critical areas where a stand of vegetation is so imperative as to justify higher costs. But, on the other hand, in heavy stands of downy chess or sagebrush and on lands with a compact surface soil, plowed furrows several feet apart may constitute the only successful low-cost method (fig. 7).

It is particularly important to cover spring- or summer-sown seed. Where seedbed preparation is impossible or too costly, it may be feasible to cover the seed by going over the area with a harrow or brush drag or by driving sheep over it to trample the seed into the

soil (fig. 8). Each of these methods has been found effective. If the soil has a tendency to puddle and bake, however, the trampling of wet soil by sheep may cause serious packing and result in failure. On slopes where it is imperative to establish grass stands as quickly as possible and where other methods are not feasible, it may be desirable to cover the seed with hand rakes. The time and expense involved make this method justifiable only on extremely critical slopes.

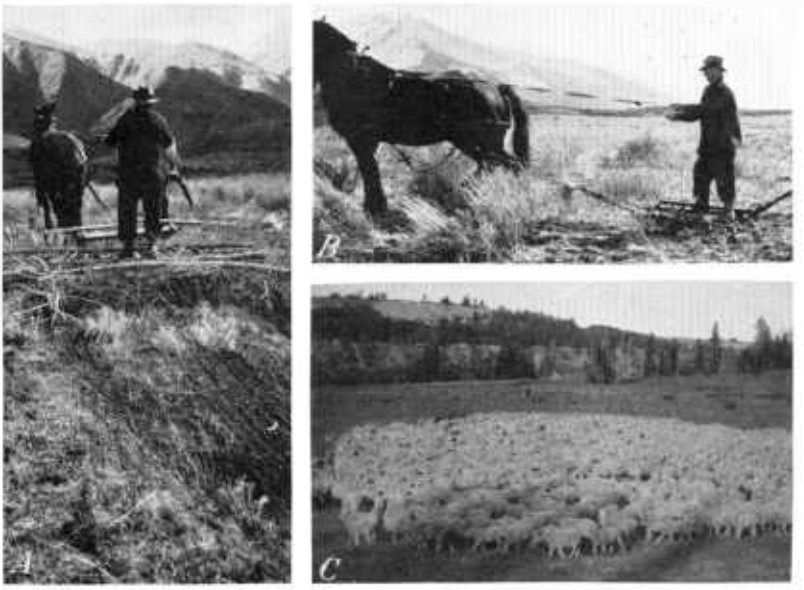

FIGURE 8.—Three methods of covering seed sown without seedbed preparation: *A*, Use of a brush drag; *B*, harrowing; *C*, driving sheep over the sown land.

DISTRIBUTING THE SEED

One-half or one-third the amount of seed used on tilled land ordinarily suffices for range land, except on especially productive soils or where needs other than forage warrant extra costs. From 5 to 10 pounds to the acre of the seed of large-seeded plants such as bromes, bluestem, and tall oatgrass is sufficient, if fairly even distribution can be obtained in sowing; and 3 to 6 pounds of that of small-seeded plants such as slender wheatgrass, and sheep fescue. When a drill is used, part of the spouts may be stopped to reduce the quantity of seed sown. Where the topography is uniform enough and woody plants or rocks do not prevent, a drill insures a fairly even distribution and a more effective covering of the seeds (fig. 9, *B*). The use of a narrow machine permits successful drilling on unusually steep slopes if precautions are taken to keep the drill from tipping over.

Hand seeders (fig. 9, *A*) require less skill in getting the seed evenly scattered, but they cannot handle large or fluffy seeds. An experienced man can obtain fairly even distribution by hand broadcasting, and this method is applicable to all types of seed; but hand sowing usually requires more seed for a given area.

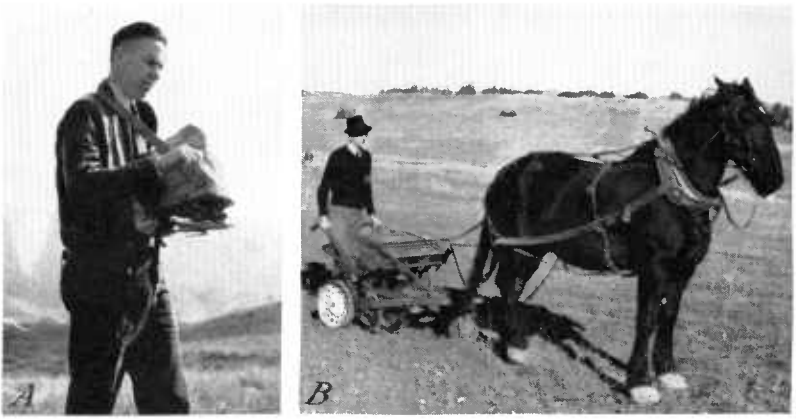

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FIGURE 9.—Some range land and most abandoned cultivated land can be reseeded most effectively and economically by broadcasting or drilling the seed: *A*, For small, smooth seeds the hand seeder is practicable and requires less skill than the drill in getting the seed evenly scattered, but it is not suitable for large or fluffy seeds; *B*, a small drill is easily managed on comparatively steep slopes and on areas broken by clumps of brush or gullies.

REVEGETATING CRITICAL AREAS

Where the welfare of dependent communities demands immediate measures to control soil erosion and to regulate stream flow, more intensive methods of revegetation than would generally be justified may be adopted. Such areas occur mostly on steep slopes where a large proportion of the rainfall runs off rapidly before it has opportunity to be absorbed by the soil. Generally a large proportion of the more productive topsoil has been washed away, leaving exposed a subsoil deficient in organic matter and available plant nutrients and hence incapable of absorbing or retaining water as effectively as the topsoils. It has a tendency to become exceedingly dry and to bake hard, affording a very poor seedbed and little nourishment for any plants that do become established. The most valuable forage plants too often either fail to start growth or die soon after. Such areas may require special measures for revegetation.

The high frequency of unpredictable drought and the serious injury it does to seedling plants often make two seedings necessary before the stand is really established, especially on the poorer soils of critical areas, where even the best methods of seedbed preparation are none too effective. Special care in getting the seed into a favorable place for germination and quick growth of the young seedlings will aid greatly in speeding up the revegetation process.

The steep slopes may have to be terraced to stop erosion while the grass plants are getting established. This has been tried with much success on the critical watershed lands of Davis County, Utah. In addition to stopping erosion, the terracing of such slopes provides a better seedbed and holds needed run-off water, thus aiding materially in the establishment of the new plants (fig. 10). Even when raw subsoil is exposed in the bottom of the terrace ditch, the surface soil washing into the trench soon provides a good seedbed.

Many raw subsoils are low in productivity because of deficiency in available plant nutrients. Agricultural experience has shown that in many instances it would be more economical to supply the necessary plant nutrients by applying some fertilizer than to sow seed repeatedly with little hope of adequate returns. The high values of watersheds for supplying irrigation water for farm lands and a domestic water supply for cities and towns may justify the expense of this treatment for many critical areas.

Barnyard manure is not generally available for fertilizing such lands, but commercial fertilizers may sometimes be used to advantage.

FIGURE 10.—A slope in Davis County, Utah, terraced before seeding. Where the values at stake warrant such expense, terracing, by providing a favorable seedbed and collecting moisture, aids materially in getting a good grass stand.

The plant nutrients most likely to be deficient are nitrogen and phosphorous. Common nitrogen fertilizers are ammonium sulphate and sodium nitrate, but there are many commercial brands of fertilizers on the market that contain this plant nutrient. The treble superphosphate commonly sold in the West is especially adapted for use on range lands on account of its concentrated form, which reduces the unit cost of transportation. Such fertilizers may usually be purchased from seed dealers. These fertilizers may be spread, either alone or in combination, at the rate of about 50 to 100 pounds per acre at the time the soil is being prepared for seeding. The fertilizer may be applied on the surface without cultivation although best results will be obtained if it is worked into the surface soil by disking, harrowing, raking, or any other means that may be found practicable.

Special consideration should be given to the selection of the species of grass to plant on the critical areas. Although it would be desirable to have a good stand of long-lived perennial grass, particularly one of the better sod-forming grasses such as smooth brome or bluestem, it may be necessary to sow small grain or a quick-growing grass with these—even an annual or one that is neither especially long-lived nor a

good soil binder—in order to help protect the area against erosion while the more permanent grasses are getting established. Plants suited for this purpose are rye, winter wheat, oats, barley, and Sudan grass in localities where the growing season is long and hot.

Rye establishes itself readily on moist soils, grows quickly, and covers the ground long before many of the more permanent grasses become established. Rye also will do fairly well on most poor soils. Although it is not permanent, it grows rapidly and will temporarily hold the soil against erosion. It also aids in the preparation of the seedbed for the better forage grasses that may be sown at the same time or later and thereby assists in their establishment. In addition to pro-

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FIGURE 11.—A transplanting of cottonwood to control erosion above a flood-control dam.

tecting critical areas against erosion and improving the soil for the establishment of other permanent grasses, these plants, on areas where grazing cannot be entirely avoided, will also produce considerable forage while the better permanent grasses are getting started.

It may even be expedient to transplant vigorously growing native or introduced grasses or other plants on critical areas to hasten revegetation, especially on bad erosion areas where shrubs and trees may also be planted. Considerable transplanting of this sort has been done recently on critical watersheds, largely through C. C. C. camps supervised by the Soil Conservation Service, Forest Service, and other agencies (fig. 11). Many native shrubs may be used for this purpose, and in most cases they are better adapted to the prevailing climatic and soil conditions than are imported species.

CARE OF NEWLY SEEDED OR PLANTED AREAS

New seedings and plantings of perennial grasses require protection for 1 or 2 years against livestock grazing and, so far as possible, against other unfavorable influences. The young plants need time

enough to establish a root system and to produce some top growth before they are grazed. Even plants that are sturdy when established may be fatally injured by trampling, by being pulled up or so loosened that they dry excessively, or by removal of the top growth before food reserves are stored in the roots and root crowns. Not much is lost by excluding grazing, for livestock gets little feed from the spindling growth produced by most grasses the first season. On critical areas, which will include practically all transplanted areas and many of those reseeded, several seasons of protection, or at least of very light grazing, will be most in keeping with the ends sought.

Grazing control is essential to the success of the reseeding project. The area grazed, the time of grazing, and the completeness of utilization by sheep may be controlled by careful herding; but fencing is surer. Since cattle are not ordinarily attended by a herder, they require fencing, except where the topography, supplemented by some drift fencing in the gaps, affords control or where the necessary control may be attained by systematic salting. Most critical areas, therefore, should be well fenced, and reseeded areas that are not critically important for watershed protection should be fenced or controlled by range riders. All the noteworthy successes cited earlier were achieved on land where livestock grazing was under control. Lack of livestock control brought many failures, even where other conditions were favorable.

Frequently, on low ranges, any open space in the plant cover develops at once a heavy stand of Russian-thistle, and any on the foothill ranges, one of downy chess. At first, either of these annual plants may retard the establishment of the new perennial plants by shading and removal of the available moisture. In the end, however, the accumulation of litter from the annuals builds up the organic matter and favors the increase of perennials. On the most critically important areas, removal of the weeds may be warranted; in all other cases the threat of erosion from removing the weedy cover is dangerous and the cost prohibitive.

A heavy infestation of rodents will require the use of some measure for control to save new plantings. Where big game is especially abundant, high fences for protection against deer may need to be provided.

COSTS INVOLVED

COST OF SEED

The major item involved in artificial revegetation is the cost of the seed, which naturally varies with the quantity required and the cost per pound. Smooth brome seed costs normally about 15 cents a pound. A minimum rate of 5 to 10 pounds to the acre to obtain a satisfactory stand makes the initial cost amount to $0.75 to $1.50 an acre for seed alone. Crested wheatgrass in 1938 and for the next few years will probably cost from 20 to 40 cents a pound, but because of the small size of the seed, the acre requirement is only about 3 to 8 pounds, making an acre cost of $0.60 to $3.20. Bluestem at a normal price of 10 to 15 cents a pound costs from $0.60 to $1.50 for 6 to 10 pounds an acre. Owing to unfavorable climatic conditions that may arise, failures may occur and two seedings may be required before satisfactory stands are established. Hence it may be necessary to

double these figures for a conservative estimate of costs except under normal conditions. The price of seed depends largely on the supply available. Recently the demand for the most favored species, such as crested wheatgrass, has exceeded the supply, resulting in increased prices where the seed is obtainable. A summary of the various items of cost is given in table 2.

TABLE 2.—*Estimates of cost* [1] *per acre of preparing seedbed; of protection against grazing, including removal of stock for 1½ years; of seeding; and of seed for artificially reseeding range lands in the intermountain region*

Method of preparing seedbed and sowing	Seedbed preparation on—			Protection [2] (exclusion of grazing)	Seeding	Seed
	Experiment plots	C. C. C. initial sowings (average)	Areas of 5 or more acres			
Seed sown broadcast on contour furrows and covered with brush drag	$2–$5	$2–$5	$1–$3	$0.03–$0.10	[3] $1	$0.60–$3.00
Seed sown broadcast on plowed contour furrows with no further treatment	2–5	.....	1–3	.03– .10	[3] 0.50	.60– 3.00
Seed sown on harrowed ground and covered with harrow	.....	1–3	1–2	.03– .10	.1 –1.50	.60– 3.00
Seed sown on harrowed ground and trampled with sheep or cattle	.....	1–3	0.75–1.25	.03– .10	.30– .75	.60– 3.00
Seed sown broadcast on unprepared ground and trampled in with sheep	.....	.....	.....	.03– .10	.30– .80	.60– 3.00
Seed sown broadcast on unprepared ground with no further treatment	.....	.....	.....	.03– .10	.30– .65	.60– 3.00
Seed drilled with team and grain drill	.....	.....	.30–.50	.03– .10	[4] 1–1.50	.50– 2.00

[1] Costs vary so widely with the economic conditions, the slope, relative smoothness, and presence or absence of brush on the range, fluctuating seed prices, accessibility, and the stockman's facilities for doing the work that the costs here presented, while actually incurred in some cases, are approximations within certain limits rather than exact figures.

[2] Includes fencing, the cost of which varies with the method—ranging from a few rods of drift fence to an entire enclosure.

[3] Rough approximation.

[4] Drilling the entire area on abandoned cultivated land without any previous preparation; and on steep slopes having neither brush nor large rocks, drilling in strips about one-third to one-half the area, leaving the unseeded strips to fill in by natural reseeding from plants that become established on the drilled strips.

LABOR COSTS

Labor costs depend on the method of sowing. Intensive methods of soil preparation and seed covering materially increase the total costs, whereas broadcast sowing followed by trampling-in the seed with livestock holds the cost to a minimum. Where labor includes soil preparation, sowing, and covering the seed, costs vary widely, as shown in table 2 for small-scale experimental plantings, initial C. C. C. projects, and areas of 5 acres or more seeded with a grain drill. Seeding on extensive areas naturally reduces the cost per acre.

COST OF PROTECTION

The cost of protecting new sowings from grazing until the plants become established varies with each site. The cost depends on the length of time protection is needed and on the local demand for pasturage. Ordinarily, adjustments in grazing can be made to relieve small areas of seeded range without material reductions in livestock. Where there is a fair amount of native forage, the range may support moderate grazing during the latter part of the second year after seeding without injury to the new seedlings. Where protection of

young plantings from grazing cannot be accomplished by adjustments in livestock on the range, the cost of full protection must be reckoned.

HIGH LIGHTS OF RESEEDING

Except for a few critical areas demanding immediate revegetation regardless of cost, range reseeding in the Intermountain region can well be confined for the present to the 4,000,000 acres having deeper soils and more favorable moisture conditions. Through research, methods may meanwhile be developed for reseeding the less favorable sites.

Some of the reseeding and transplanting will probably be undertaken with public funds on a project basis. Such work may be either on public land or on private land having high values for, or constituting serious hazards to, the public welfare. The major effort, however, will probably be made by stockmen on their own land, for the purpose of increasing the forage production.

The most promising plants for reseeding in high mountains are mountain and smooth bromes, slender wheatgrass, and bluestem. Only in wet or moist meadows have Kentucky bluegrass and timothy done well. In the foothills and upper valley edges, slender and bluebunch wheatgrasses have done better than other grasses on rough land, and bluestem does well on moist, fine-textured soils; crested wheatgrass has succeeded, especially on abandoned dry farms in the northern part of the region; rye and alfalfa have shown promise on the better soils of some abandoned cultivated land. On the desert areas no great success has as yet been obtained.

Early spring or preferably late autumn is the best time for reseeding, except on high mountains where summer rains make July or August the most favorable seeding time.

Sowing on abandoned dry farms and moderately level range not covered with brush is best done with a grain drill; on rough or brush-covered range, with a broadcasting machine or by hand in coutour furrows or after harrowing. In the latter cases, seed should be covered as effectively as possible with a harrow or brush drag or by trampling in with sheep.

New plantings need full protection against grazing for the first season and until late in the second season, when they may be subjected to very light grazing.

Plowing makes the labor cost so high that it is seldom justifiable. Contour furrowing is much cheaper and may be warranted where the nature of the ground favors its use. Where forage is the principal form of return, lower labor costs are sought by drilling the seed without previous soil preparation, or by broadcasting and covering the seed as inexpensively as possible. Seed costs may be decreased by thin sowing or seeding in strips. Even on good soils, however, costs are sometimes increased by the necessity for a second seeding, owing to the failure of the first as a result of untimely drought.

On critical watersheds, extra costs in labor and fertilizer may be warranted in order to speed up revegetation. In some cases transplanting is needed.

Reasonable success from reseeding may be expected at moderate cost when (1) areas having average-or-better soil and moisture conditions are chosen, (2) only a thin stand of vegetation is present,

(3) seed of species that have proved successful is sown, (4) the seed is so sown as to be covered with soil, and (5) grazing on the area is adequately controlled.

COMMON AND BOTANICAL NAMES OF SPECIES DISCUSSED

Alfalfa	*Medicago sativa.*
Big sagebrush	*Artemisia tridentata.*
Bitterbrush	*Purshia tridentata.*
Bluebunch wheatgrass	*Agropyron spicatum.*
Blue pentstemon	*Pentstemon glaber.*
Bluestem	*Agropyron smithii.*
Bulbous bluegrass	*Poa bulbosa.*
Crested wheatgrass	*Agropyron cristatum.*
Downy chess	*Bromus tectorum.*
Gambel oak	*Quercus gambelii.*
Kentucky bluegrass	*Poa pratensis.*
Letterman needlegrass	*Stipa lettermani.*
Meadow fescue	*Festuca elatior.*
Mountain brome ("California brome;" "big brome").	*Bromus carinatus* (*syns. B. marginatus; B. polyanthus*).
Mountain mahogany	*Cercocarpus montanus.*
Muttongrass	*Poa fendleriana.*
Needlegrasses	*Stipa* spp.
Orchard grass	*Dactylis glomerata.*
Russian-thistle	*Salsola pestifer.*
Rye	*Secale cereale.*
Ryegrasses	*Lolium* spp.
Serviceberries	*Amelanchier* spp.
Sheep fescue	*Festuca ovina.*
Slender wheatgrass	*Agropyron pauciflorum.*
Smooth brome	*Bromus inermis.*
Snowberry, mountain	*Symphoricarpos oreophilus.*
Sudan grass	*Sorghum vulgare* var. *sudanense.*
Tall oatgrass	*Arrhenatherum elatius.*
Timothy	*Phleum pratense.*
Velvet grass	*Holcus lanatus.*
Wild-ryes	*Elymus* spp.

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